Shale Gas Development in the Central Karoo: *A Scientific Assessment of the Opportunities and Risks*

PREFACE

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1. BACKGROUND

The potential economic and energy security benefits of a large shale gas resource in the Karoo Basin could be substantial; as are both the positive and negative social and environmental issues associated with a domestic gas industry. Shale gas development[1] (SGD) has already become a highly divisive topic, but one which is poorly informed by publically-available evidence.

To address this lack of critically-evaluated information, a Strategic Environmental Assessment (SEA) for SGD was commissioned in February 2015 by the Department of Environmental Affairs of the Republic of South Africa, with the support of the National Departments of Energy, Mineral Resources, Water Affairs and Sanitation, Science and Technology, and Agriculture, Forestry and Fisheries; and the Provincial Departments of the Eastern, Western and Northern Cape Governments.

The Council for Scientific and Industrial Research (CSIR) coordinated the SEA, in partnership with the South African National Biodiversity Institute (SANBI) and the Council for Geoscience (CGS). In addition to the national science councils, the SEA includes 146 independent authors contributing to the 18 Chapters of the assessment. The Chapters have been independently reviewed by a further 25 local and 46 international independent peer review experts, and by a large number of stakeholders.

The point of departure for the SEA is that South African Government, through Cabinet and various other decision-making institutions, has made high-level public commitments to shale gas *exploration*.

If the exploration phase reveals economically-viable hydrocarbon deposits and gas-flow regimes, the Government will seriously consider permitting the development of those resources at significant scale. South African society, collectively comprising all levels of government, the private sector and civil society, needs to be in a position to make the decisions relevant to that choice in a timely and responsible manner.

The mission statement for the SEA is to provide an integrated assessment and decision-making framework to enable South Africa to establish effective policy, legislation and sustainability conditions under which SGD could occur. Note that this mission statement, developed in collaboration with government, is phrased in the conditional - it does not presume that SGD *will* occur.

[1] The terms “shale gas development”(SGD) refers to all exploration and production related activities, as well as downstream gas utilisation scenarios, encompassing the full life-cycle of impacts typical of a SGD programme. In Chapter 1 (Burns et al., 2016), clear distinction is made between the phases of SGD to distinguish the nature and extent of SGD activities which can be logically assumed across the scenarios.

The key objective of the SEA is to provide decision makers and stakeholders with an evidence base which will assist South Africa in developing a better understanding of the opportunities and risks associated with SGD. The SEA is not in itself a mandated decision-making process. The intention of the SEA is to provide the evidence base and decision support frameworks which will guide future decision-making processes, for example those associated with Environmental Impact Assessments (EIA) for specific SGD-related activities, once it becomes clear exactly what those are and where they might be located.

2. PHASED APPROACH

The SEA has three distinct but overlapping Phases (Figure 1). *Phase 1*, beginning in February 2015, and extending to around October 2015 was the Preparation Phase.

The Preparation Phase included the necessary arrangements involving contracts and procurement arrangements, recruitment, convening governance structures, collating literature and data libraries, identifying the multi-author expert teams, undertaking team training, arranging logistics and writing the First Order Draft (FOD) of Chapter 1.

Phase 2 of the SEA is the scientific assessment phase, where information was organised by the multi-author expert teams, including two review rounds of their Chapters, initially by independent review experts, and then (following revision to produce the Second Order Draft [SOD])

Preface Box 1: What is a Scientific Assessment?

Scientific assessments are aimed at the stakeholders (often specifically decision-makers) in society, who are intelligent but not necessarily technical specialists. The questions are posed by the stakeholders, who help to shape the assessment. Strong attempts to use jargon-free, plain language, summary tables and explanatory diagrams are made. Scientific assessments have a strong focus on balanced and inclusive governance to establish legitimacy and credibility.

The issues addressed are investigated by large and diverse teams of experts. During assessments, subjective judgements are often required, but these are made explicitly, along with statements of confidence. Balance and the elimination of bias are achieved through the establishment of broad multi-author teams representing a range of interests and/or positions, coupled with extensive and transparent review.

The assessment is independently reviewed by other experts and by stakeholders, often amounting to thousands of documented comments and responses, all of which are available in the public domain. Scientific assessments are appropriate to problems which are both technically complex and socially contested; they are policy relevant, but not policy prescriptive.

The first of the modern scientific assessments of a complex, socially-important problem is usually considered to be the Ozone Assessment of 1986. The success of this exercise in paving the way for the Montreal Protocol led to the formation of a permanent assessment body for climate change, the Intergovernmental Panel on Climate Change, in 1990, before the United Nations Framework Convention on Climate Change was signed. The successive climate scientific assessments from 2000, 2007 and 2014 are credited with making possible the agreement by 195 countries in Paris in December 2015 to take concerted action on climate change.

by stakeholders plus experts. *Phase* 2 commenced with the first author meeting on 28 September 2015, and ended with the completed final scientific assessment report – this published volume.

Phase 3 of the SEA will translate the scientific assessment into an operational Decision Making Framework. It is undertaken by the statutory science councils - CSIR, SANBI and CGS - in close consultation with the various affected National and Provincial Departments. It commences with initial drafts after the delivery of the SOD, and continues into the final revision of the scientific assessment report. *Phase* 3 of the SEA concludes around March 2017 and will provide the framework for how site and activity specific assessment processes should be undertaken and provide Government with the necessary tools to enable responsible decision-making into the future regarding SGD. This includes guidance on legislation, regulations, EIA processes and monitoring.

The separation between *Phase* 2 and *Phase* 3 is to honour the scientific assessment 'mantra' of being "policy relevant, but not policy prescriptive". The experts involved in *Phase* 2 have not been asked to make decisions about the development of shale gas. They have been asked to give an informed, evidence-based, scientifically-sound and balanced opinion on the consequences of different scenarios and development options for SGD into the future. The ultimate decisions regarding future authorisation processes for shale gas, whether at a national, provincial or local level, will be made by the authorities mandated to do so. In making these decisions they will be guided by the SEA and any other relevant and trusted sources of information that may have become available between the completion of the SEA and the time at which they need to implement policy, which may be years or decades into the future.

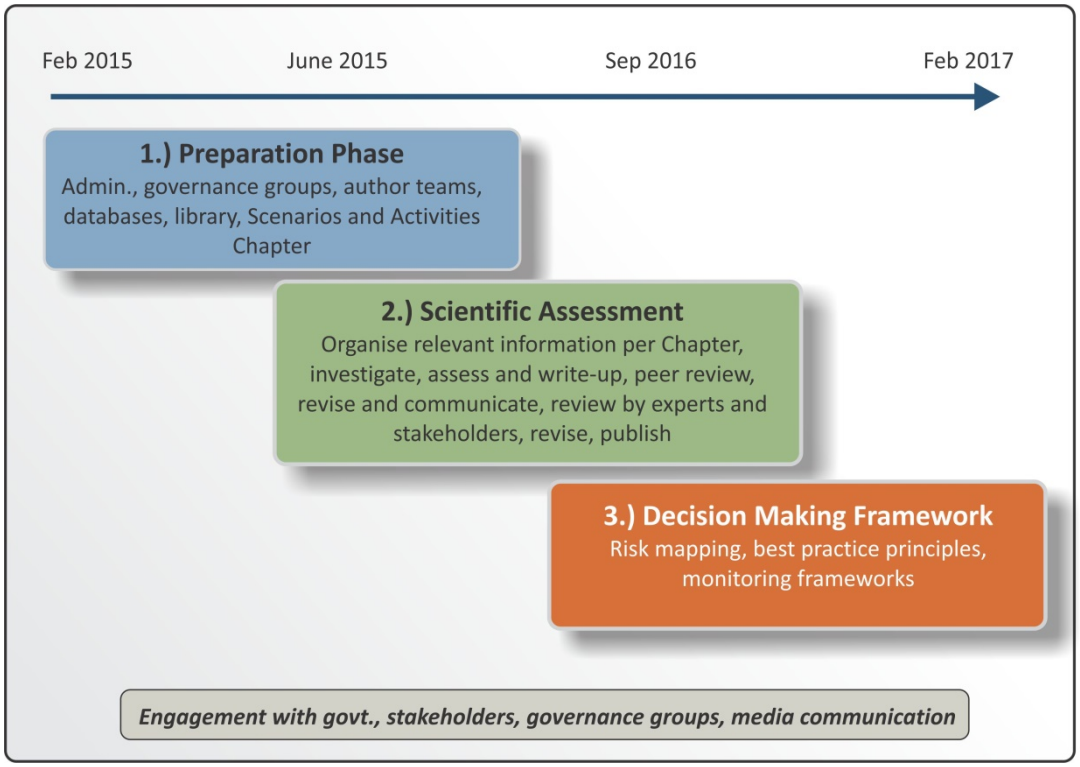

Figure 1: Shows the 3 overlapping phases of the SEA process and how the scientific assessment is used as the evidence base from which to develop an appropriate Decision Making Framework.

3. STRUCTURE OF THE SCIENTIFIC ASSESSMENT

The *Preface* provides the background to the study, explaining why it was commissioned, how it is phased, how it is governed and the manner in which it has been undertaken.

The *Summary for Policy Makers* (SPM) synthesises the key policy-relevant issues arising from the 18 Chapters which make up the body of the scientific assessment, into a form useable for policy makers and stakeholders. The SPM highlights the most salient points and findings of the assessment, each of which is supported by an evidentiary base, located in the Chapters. The location of the evidentiary base is indicated by the symbol '§'. Each section and series of statements contained in the SPM is traceable to a specific source, where further information can be retrieved by anyone interested.

Preface Box 2: Report Structure

…	*Preface*
…	*Summary for Policy Makers*
Ch 1	Shale Gas Development Scenarios and Activities
Ch 2	Effects on National Energy Planning and Energy Security
Ch 3	Air Quality and Greenhouse Gas Emissions
Ch 4	Earthquakes
Ch 5	Water Resources, both on the Surface and Underground
Ch 6	Impacts on Waste Planning and Management
Ch 7	Biodiversity and Ecological Impacts: Landscape Processes, Ecosystems and Species
Ch 8	Impacts on Agriculture
Ch 9	Impacts on Tourism in the Karoo
Ch 10	Impacts on the Economy
Ch 11	Impacts on Social Fabric
Ch 12	Impacts on Human Health
Ch 13	Impacts on Sense of Place Values
Ch 14	Impacts on Visual, Aesthetic and Scenic Resources
Ch 15	Impacts on Heritage
Ch 16	Noise Generated by Shale Gas-Related Activities
Ch 17	Electromagnetic Interference
Ch 18	Impacts on Infrastructure and Spatial Planning

The purpose of Chapter 1, is to describe the nature and scale of activities assumed for three SGD scenarios of increasing magnitude. The scenarios are described in the context of a reference scenario where there is no SGD. The scenarios are selected to cover a range of plausible futures. Chapter 1 serves as a common point of departure for the 17 subsequent Chapters, which evaluate, for the issues on which they focus, the levels of opportunity and risk associated with each of the scenarios and their main defining activities.

Chapters 2-18 are topic specific - they constitute the *actual* assessment. Each Chapter has been structured in a manner which presents a clear definition of the scope of the topic in question, a review of the international literature and evidence, the relevant South African rules, institutions, regulations

and legislation; and a description of the key SGD impacts and mitigation options. Each Chapter goes through a systematic and structured risk assessment of the impacts described, assessed both with and without mitigation, and across the three development scenarios relative to the reference case and relative to the '*levels of acceptable change*'. Levels of acceptable change relate to the societal judgements based on historical trends (what have people been happy to accept in the past, and implicit in the baseline); guiding legislation, regulations and international norms; and absolute biophysical or social thresholds.

On the back of the risk assessment, undertaken per Chapter, the multi-author teams make recommendations regarding impact mitigation best practice in relation to that topic; and baseline and ongoing monitoring requirements. The teams also clearly identify, per Chapter, the areas in which there was inadequate information to adequately inform decision-makers and society.

A detailed list of glossary terms and abbreviations is provided in Appendices 1 and 2 respectively. Appendix 3 provides summary biosketches of the Integrating and Contributing Authors who have drafted the Chapters of the scientific assessment (Table 3).

Preface Box 3: Principles of a Scientific Assessment: Legitimacy, Saliency and Credibility

Legitimacy refers to running an unbiased process which considers appropriate values, the concerns and perspectives of different actors, and corresponds with political and procedural fairness. Furthermore, the process must include appropriate people and organisations within project governance structures to ensure that the process is considered legitimate in the eyes of both the public and the decision-makers tasked with using it.

Saliency is established by ensuring that the outcomes of the assessment are of relevance to the public and decision-makers and seeks to address quite specific questions, in other words, a scientific assessment is not a research project. The assessment must consider all the material issues and legitimate stakeholder concerns associated with SGD.

Credibility means meeting the standards of scientific rigor and technical adequacy. The sources of knowledge in an assessment must be considered trustworthy along with the facts, theories, and causal explanations invoked by these sources. Local and traditional knowledge should be included in the assessment where appropriate and possible. Involving eminent and numerous scientists as authors and ensuring that all reports undergo expert peer review are essential.

4. SCIENTIFIC ASSESSMENT PROCESS

The Zero Order Draft (ZOD) of the scientific assessment, which provided a 'skeletal structure' of the full assessment and the range of topics covered, was released for public comment in October 2015; and discussed and communicated with stakeholders at public briefings in November 2015 and May 2016. The scope of work for the assessment was vetted by the Process Custodians Group (PCG) and Project Executive Committee (PEC) (see Section 8).

Based on the ZOD, the multi-author teams drafted the Chapter FODs, which were received by the management team in February 2016. The Chapter FODs were distributed for independent expert peer review. All peer review comments on the FODs were captured by the management team and sent back to the Chapter teams prior to the second author meeting in April 2016.

The SODs, which now included the revisions made following peer review and the responses by the author teams to the peer review comments, were submitted to the management team end-May 2016. The SODs constituted the draft scientific assessment, which were released for stakeholder comment for a 38 day period. All stakeholder comments submitted on the SODs were captured and responded to in a formal manner by the Chapter teams during the third and final revision of the scientific assessment and have been released publically on the project website.

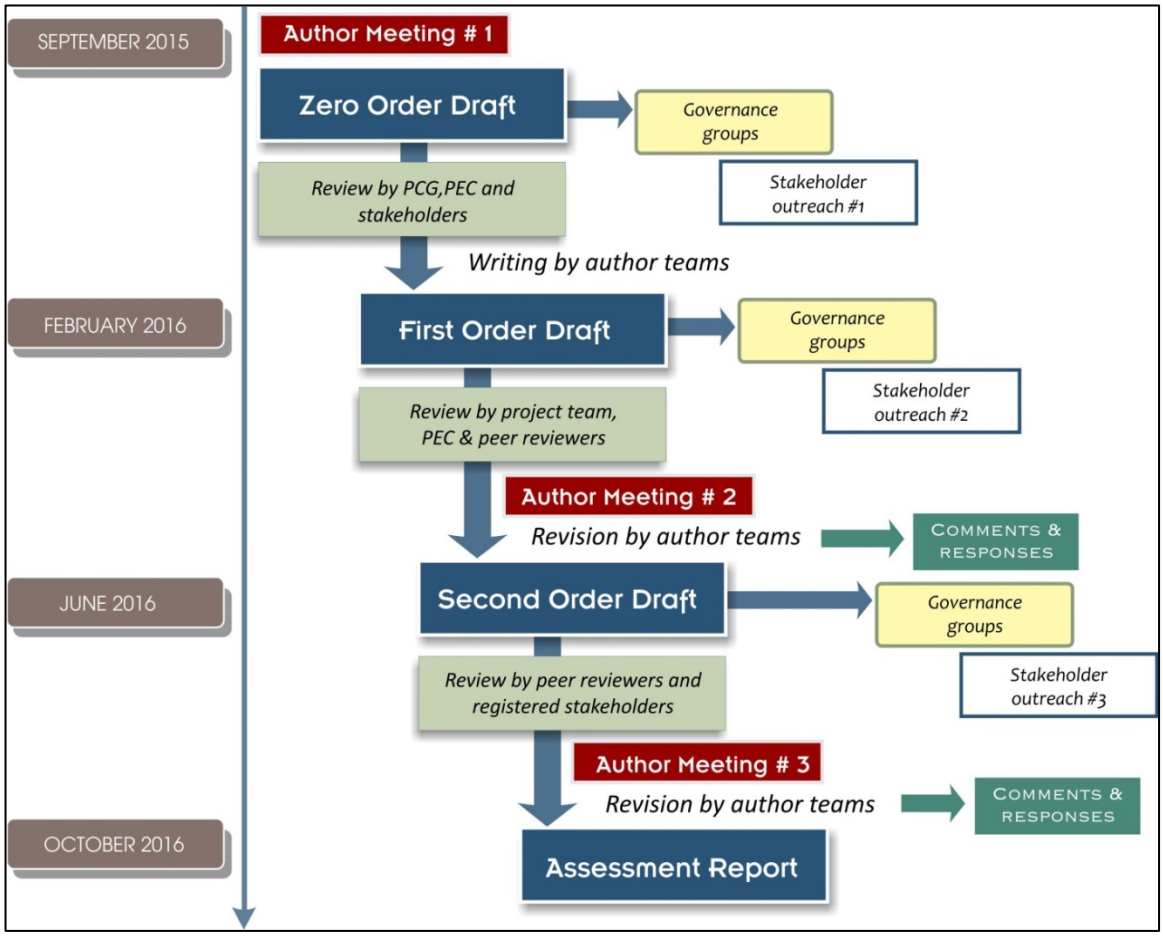

Figure 2: The scientific assessment process initiated with Author Meeting # 1 and the production of the ZOD in September and October 2015 respectively; and was completed with the publication of the final scientific assessment report at the end of 2016.

5. SCOPE OF THE SCIENTIFIC ASSESSMENT

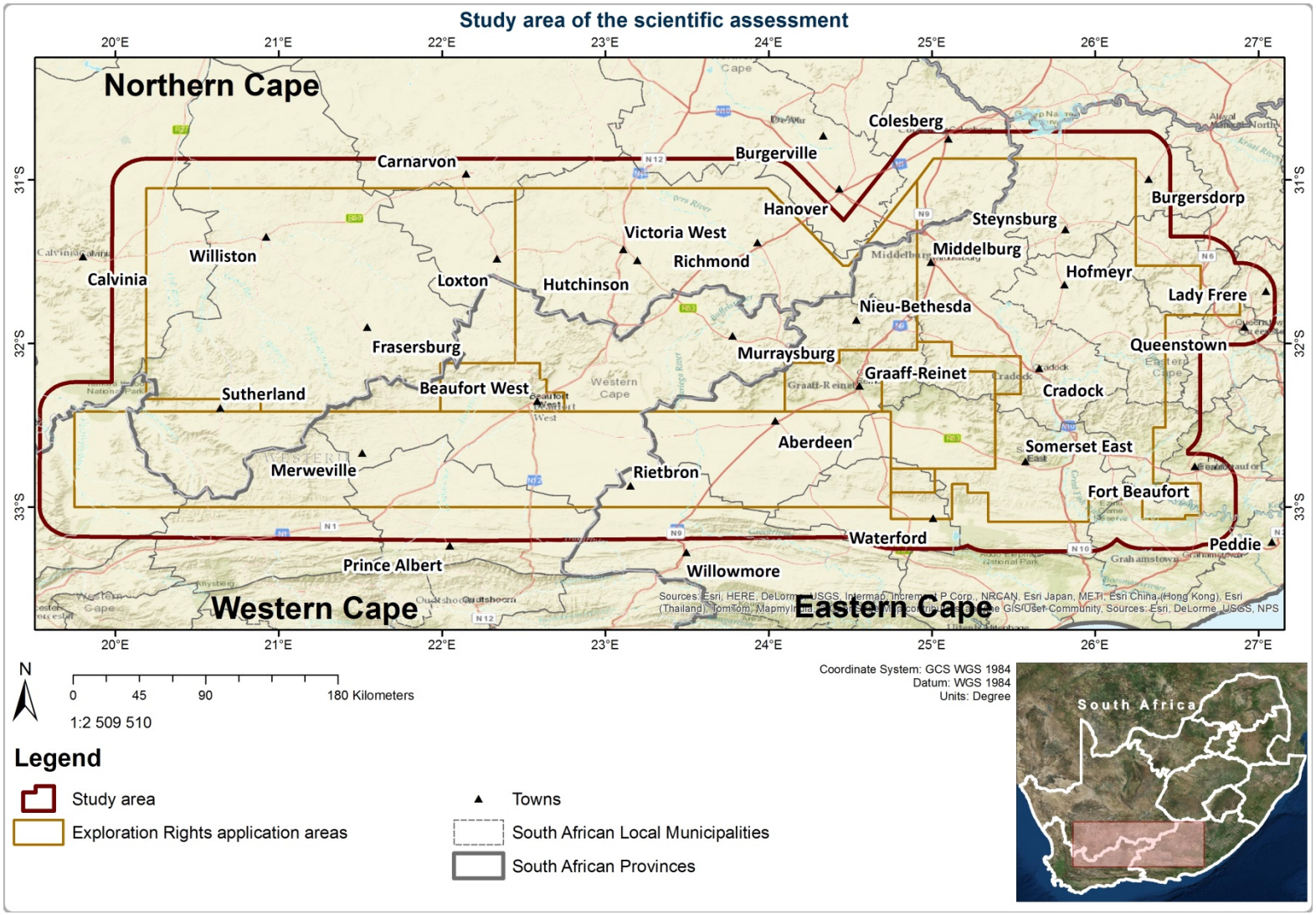

Figure 3: The Scientific Assessment considers SGD origination in the 171 811 km^2 region of the study area delimited by the applications for Exploration Right which have been lodged by Shell, Falcon and Bundu), plus a 20 km buffer. The assessment follows the consequences of SGD in this region to the point of material impact, even if that is outside the study area.

The geographic scope of the assessment was restricted to the potential impacts originating from SGD within the Central Karoo (Figure 3). This is not only the most promising SGD prospect, but also the only one at the date of commencement, for which Exploration Right applications (specifically for shale gas) had been accepted by the Petroleum Agency South Africa (the Exploration Right applications are currently still under consideration).

Other types of unconventional gas reserves may exist in other areas of the South African onshore and offshore territory, and would need separate consideration if their development was considered. The scope of this scientific assessment considers shale gas exploration, production and downstream related activities, up to and including eventual closure of facilities and restoration of their sites (collectively called "development"), and includes an assessment of all the material social, economic and biophysical opportunities and risks associated with the shale gas industry across its entire lifecycle, as described in Chapter 1 (Burns et al., 2016). This temporal scope extends, in some instances up to 40 years into the future. The scope of issues addressed in the scientific assessment (Figure 4) was informed by an in-depth review of similar international assessments undertaken around the world and by engagement with stakeholders and governance groups.

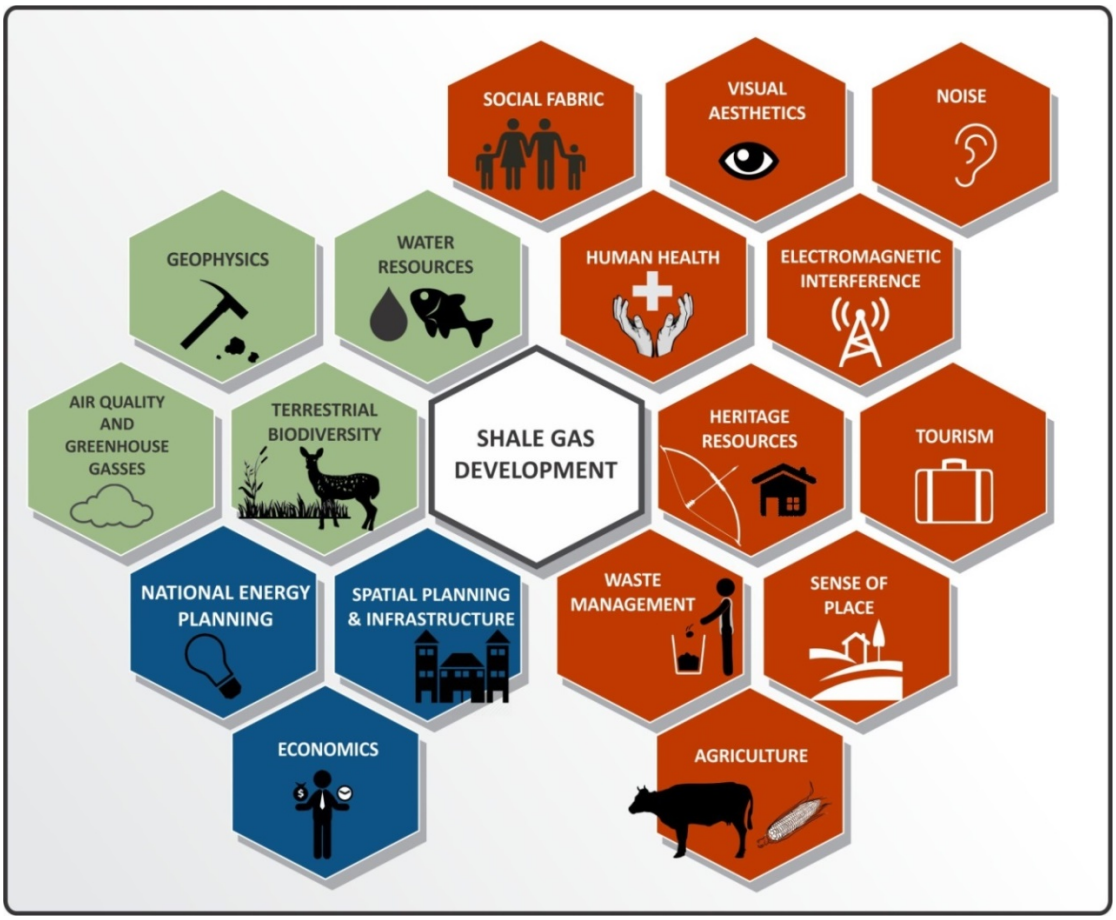

Figure 4: The 17 strategic issue topics identified through the literature review and public / governance engagement process, which now form the basis of the scientific assessment.

6. RISK ASSESSMENT METHODOLOGY

Each Chapter undertakes a rigorous and systematic risk assessment of the impacts relating to SGD. The risk assessment approach takes its point of departure from the fact that there is residual uncertainty about all aspects of the future, even after that uncertainty has been constrained by rigorously assessing the evidence.

The risk assessment, which is based on a transparent expert judgement process, is an approach for considering all impacts of an issue in a common way, and (where possible) within a spatial context. Risk is determined by estimating the *likelihood* of events or trends occurring, in relation to their *consequences* i.e. *likelihood x consequence = risk* (Figure 5). A low-likelihood, high consequence impact could be just as 'risky' as a high probability, low consequence impact. The consequence terms ranging from slight to extreme are calibrated per Chapter topic so that there is consistency in way risk is measured, allowing for suitable integration across different Chapters and disciplines.

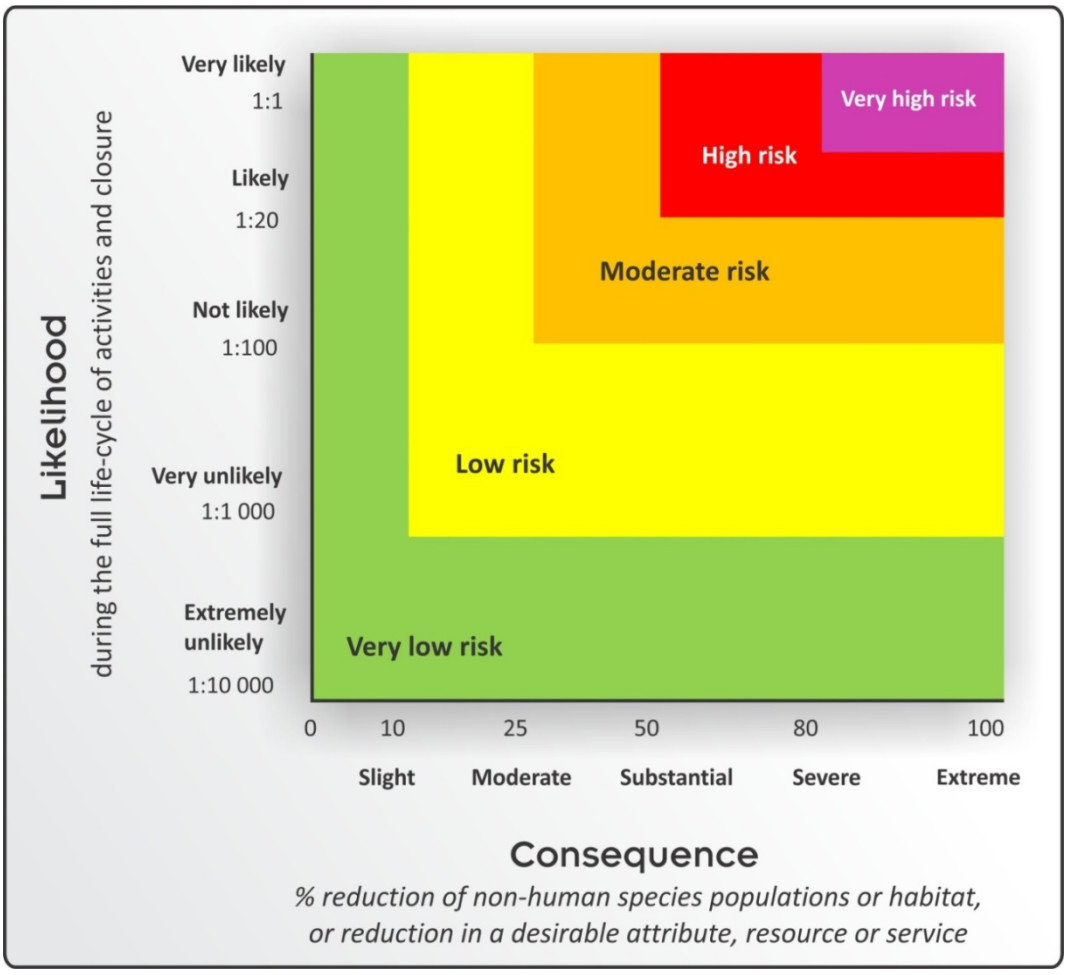

Figure 5: Risk is qualitatively measured by multiplying the likelihood of an impact by the severity of the consequences to provide risk rating ranging from very low, low, moderate, high and very high.

The consequence of an impact depends on three things: 1.) *Exposure to the impact*: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected. 2.) *The nature of the impact*: The potential occurrence of a natural or human-induced physical event or trend that may cause negative impacts such as health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. 3.) The *vulnerability of the receiving environment*: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

The risk assessment is based on an interpretation of existing spatial and non-spatial data in relation to the proposed activities described in the scenarios, to generate an integrated picture of the risk related to a specified activity in a given location, with and without mitigation. Risk is assessed for each significant stressor (i.e. impact), on each different type of receiving entity (e.g. the rural poor, a sensitive wetland etc.), qualitatively (undiscernible, very low, low, moderate, high, very high) against a predefined set of criteria (Table 1).

Table 1: Predefined set of criteria applied across the Chapters of the scientific assessment

Risk category	Definition
No discernible risk	Any changes that may occur as a result of the impact either reduce the risk or do not change it in a way that can be differentiated from the mean risk experienced in the absence of the impact.
Very low risk	Extremely unlikely (<1 chance in 10 000 of having a consequence of any discernible magnitude); or if more likely than this, then the negative impact is noticeable but slight, i.e. although discernibly beyond the mean experienced in the absence of the impact, it is well within the tolerance or adaptive capacity of the receiving environment (for instance, within the range experienced naturally, or less than 10%); or is transient (< 1 year for near-full recovery).
Low risk	Very unlikely (<1 chance in 100 of having a more than moderate consequence); or if more likely than this, then the impact is of moderate consequence because of one or more of the following considerations: it is highly limited in extent (<1% of the area exposed to the hazard is affected); or short in duration (<3 years), or with low effect on resources or attributes (<25% reduction in species population, resource or attribute utility).
Moderate risk	Not unlikely (1:100 to 1:20 of having a moderate or greater consequence); or if more likely than this, then the consequences are substantial but less than severe, because although an important resource or attribute is impacted, the effect is well below the limit of acceptable change, or lasts for a duration of less than 3 years, or the affected resource or attribute has an equally acceptable and un-impacted substitute.
High risk	Greater than 1 in 20 chance of having a severe consequence (approaching the limit of acceptable change) that persists for >3 years, for a resource or attribute where there may be an affordable and accessible substitute, but which is less acceptable.
Very high risk	Greater than even (1:1) chance of having an extremely negative and very persistent consequence (lasting more than 30 years); greater than the limit of acceptable change, for an important resource or attribute for which there is no acceptable alternative.

In Chapters 2-18, every author team has conducted a risk assessment in relation to its issue, starting in the FOD, and then refining the assessment in subsequent drafts as a result of independent peer and stakeholder review processes. The risk assessments are conducted using the standardised approach described and terminology has been standardised to improve consistency across the Chapters.

The risk assessment is spatially explicit – each Chapter (where spatial data was available), defines different receiving environments in the form of a spatial Geographic Information System (GIS), generally based on sensitivity, then assesses each impact under the three scenarios in relation to the Reference Case, without mitigation first, and then with mitigation (assuming the application of the best practice management principles applied). The without and with migration assessment provides a plausible range of future outcomes across the scenarios, assuming no mitigation, where there is poor governance capacity and decision-making; to with mitigation, which assumes adequate governance capacity and decision-making.

7. SCENARIOS AND ACTIVITIES

The purpose Chapter 1 (Burns et al., 2016) is to describe, in as much detail as feasible, the scale and type of activities which would logically be associated with three SGD scenarios of increasing magnitude, in relation to the Reference Case which assumes other changes, but no SGD (Table 2, Figure 6).

The Chapter serves as a common point of departure for the subsequent 17 Chapters, to estimate, for the Chapters, the levels of risk associated with each of the scenarios, considering the activity descriptions. As such, Chapter 1 is not itself an assessment, and nor does it make any suggestion about how likely or desirable any of the scenarios are. It simply provides a shared basis from which risk is estimated across the scenarios, across the activities and across the Chapter topics which will follow in due course.

The scenarios depicted in the Chapter do not presuppose that SGD will occur. They are presented in a plausible but hypothetical manner so that the ‘strategic-level’ opportunities and risks associated with the likely range of scenarios can be estimated. The outcome of that assessment will inform responsible decision-making with respect to SGD at a site specific level, when or if applications are made by the oil and gas industry to pursue further pursue exploration in the Central Karoo.

Table 2: Scenarios considered in the assessment and a brief explanation of the associated activities. Tcf is trillion cubic feet of gas. For comparison, the Mossgas resource at Mossel Bay was about 1 Tcf.

Scenario	Brief explanation
Scenario 0: Reference Case	No SGD. Regional trends such as human migration, shifting economic activities and new development alternatives in the Central Karoo are realised. Climate change reduces the availability of water in the region.
Scenario 1: Exploration Only	Exploration proceeds, with results indicating that production would not be economically viable. All sites are rehabilitated, drilled wells are permanently plugged and monitoring of the abandoned wells is implemented. The national energy supply is supported by imported natural gas either via pipeline or from Liquefied Natural Gas (LNG) importation.
Scenario 2: Small Gas	A relatively small but economically viable shale gas discovery is made, in the region of 5 trillion cubic feet (Tcf) produced from 550 wells on about 55 wellpads in one 30 x 30 km production block. Downstream development results in a 1 000 megawatt (MW) combined cycle gas turbine (CCGT) power station located less than 100 km from the production block.
Scenario 3: Big Gas	A relatively large shale gas discovery of 20 Tcf is made, produced from 4100 wells on about 410 wellpads distributed across four production blocks. Downstream development results in construction of two CCGT power stations (each of 2 000 MW generating capacity) and a gas-to-liquid (GTL) plant located at the coast with a refining capacity of 65 000 barrels (bbl) per day.

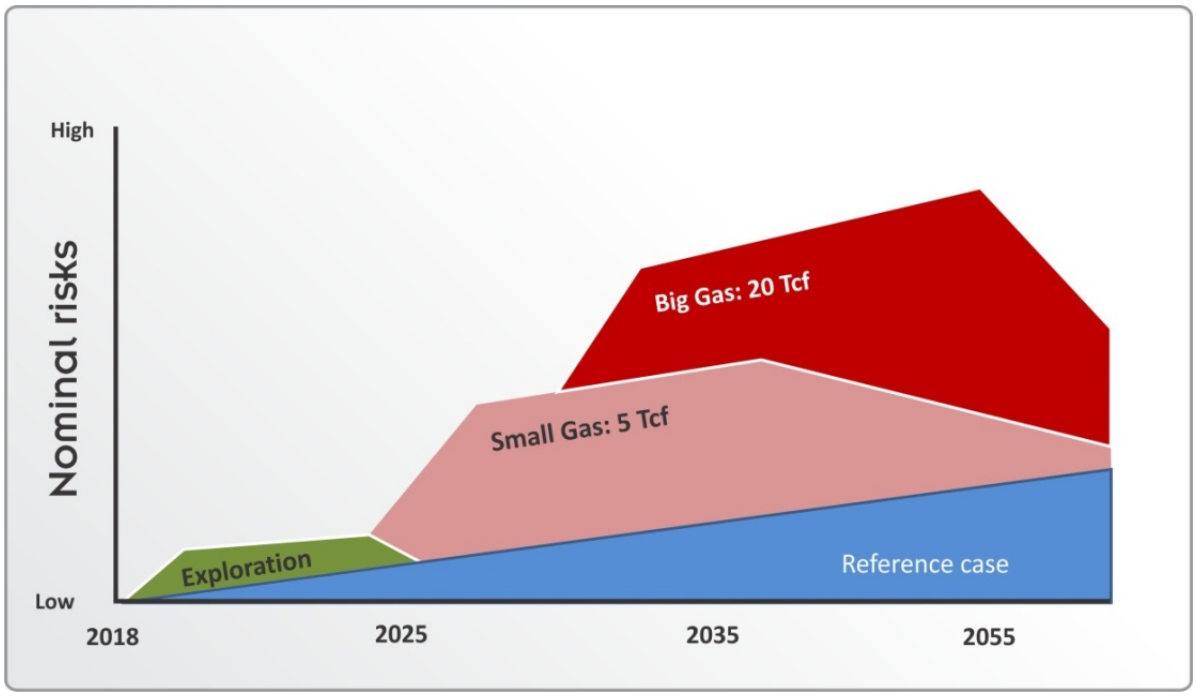

Figure 6: A 'cartoon' of the four conceptual scenarios to be considered in this assessment. Note that the scenarios are cumulative: Scenario 1 (Exploration Only) includes Scenario 0 (Reference Case); Scenario 2 (Small Gas) includes 1 and 0; and Scenario 3 (Big Gas) includes 0, 1 and 2. Thus they extend from 2018 to beyond 2055.

8. PROJECT GOVERNANCE

The Project Executive Committee (PEC) comprises representatives of Government who commissioned the SEA. The key responsibilities for the PEC include are as a project oversight body – coordinating and communicating information about the process, ensuring the project remains on scope, within timelines and budget and that strategic and policy issues are adequately addressed.

A key innovation, used specifically for the scientific assessment (*Phase 2)*, is the Process Custodians Group (PCG). The PCG is designed to ensure that the scientific assessment is independent, thorough and balanced. The PCG comprised approximately 16 eminent people, drawn approximately equally from government, NGOs, the private sector and the research community. The PCG met at key junctures during the scientific assessment to ensure that the process has been fair and rigorous. The PCG acted as a 'process referee' to ensure that the assessment had been undertaken in a legitimate, transparent and credible manner.

The organisations from which the PCG members were sourced were selected by the PEC as having credibility in their 'sectors' through having a mandate of some distinction, broad representation and a demonstrated interest in the topic of SGD. Members of the PCG are not appointed as 'representatives' of their organisation in a narrow sense; but were expected to reflect the breadth of opinion in their sectors. The PCG was neither 'approving' nor 'disapproving' of SGD, nor did it have a say on the detail of the content of the scientific assessment. It was a trustworthy collective, tasked with ensuring that the process of evidence collection, evaluation and presentation was comprehensive and unbiased. This distinction remained critical especially for the non-governmental members of the PCG, as they and their respective organisations did not necessarily agree with every outcome of the assessment.

The PCG provided feedback to the PEC, ensuring that the scientific assessment was followed within the prescribed process as approved in the SEA Process Document[2]. Their specific mandate was to evaluate the following five topics of the assessment *process*:

1.) Has the assessment process followed within the guidelines of the SEA Process Document?
2.) Do the Chapter teams have the necessary expertise and show balance?
3.) Does the assessment (as indicated by the Zero Order Draft) cover the material issues?
4.) Are the identified expert reviewers independent, qualified and balanced?
5.) Have the review comments received from expert and stakeholders been adequately addressed and have the responses been adequately documented?

[2] The SEA Process Document downloadable at http://seasgd.csir.co.za/library/

The PCG convened during the scientific assessment to discuss the ZOD in October 2015, the Scenarios and Activities Chapter FOD and SOD in October 2015 and May 2016 respectively, and the FODs of the 17 strategic issue Chapters comprising the scientific assessment in May 2016. Feedback to the PCG was also provided on the progress of stakeholder engagement, public outreach processes and stakeholder commenting mechanisms. The final PCG meeting was undertaken end-September 2016. No objections to the *process*, as outlined in the mandate of the PCG, we registered before final publication of the scientific assessment.

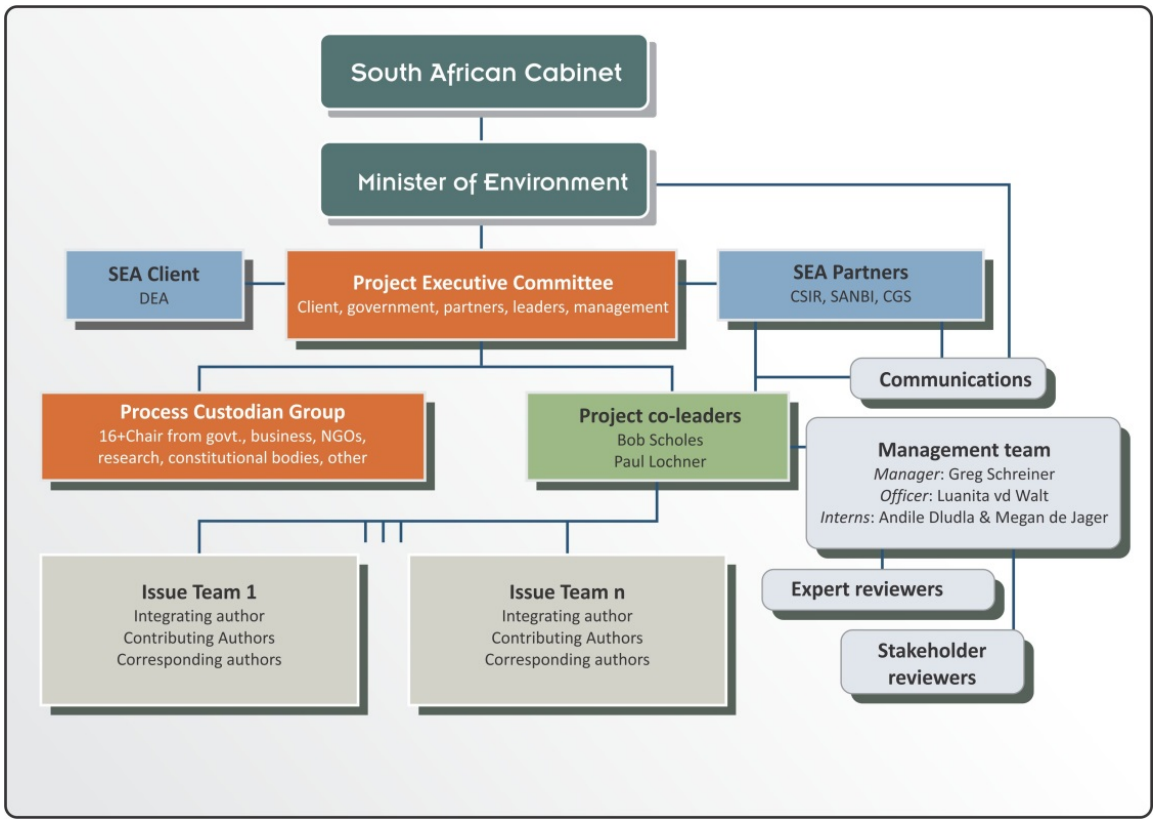

Figure 7: The project governance structure of the entire SEA process showing the interaction between the two governance groups, the SEA partners, the co-leaders and management team, the multi-authors teams, the peer review experts and stakeholders.

9. THE MULTI-AUTHOR TEAMS

In order to advance the principles of balance and comprehensiveness, the main topics in the assessment have been addressed by multi-author teams, rather than the approach often applied in EIAs of using a single expert or consulting group. Each of the Chapters has a team of three to 20 authors - all selected on the basis of their acknowledged *expertise*.

Expertise is usually evidenced by appropriate formal qualifications and experience, but may also be evidenced by widespread peer-group agreement that the candidate has expertise on the topic and by a

track record of outputs, widely acknowledged to be of value. Authors have been drawn from a broad range of sectors, including research institutions, consultancies, government, NGOs and universities, and across different regions of South Africa, to ensure a balance of interests, disciplinary background, experience and perspective is represented in the teams.

Each team includes one (in some cases two) Integrating Author/s, several Contributing Authors and potentially many Corresponding Authors (Table 3). The latter did not attend writing meetings, but provided small amounts of text on defined, relatively narrow topics, via email. Authors of the 18 Chapters do not represent their home organisations or any particular constituency. They were selected on a personal basis, reflecting their individual capacity to contribute to the scientific assessment.

Table 3: The three author roles and associated responsibilities in drafting the assessment chapters

Integrating Authors	The ***Integrating Authors*** were responsible for ensuring that all the components written by Contributing and Corresponding Authors were delivered on time, and were incorporated in a logical fashion in each Chapter; and that the scope of the Chapter, as decided at the first workshop, was covered. Integrating Authors ensured that the responses to comments from stakeholders and peer reviewers have been adequately addressed and/or incorporated and documented.
Contributing Authors	The ***Contributing Authors*** were expected to attend all three writing workshops and actively participate in the discussions and decisions there. They delivered text, references, tables and graphics to their Integrating Author/s by agreed dates, and according to agreed formats and templates. They assisted in addressing reviewer comments (especially those relating to text they have contributed).
Corresponding Authors	The ***Corresponding Authors*** typically (although not always) wrote less than one published page - often a box, a table, illustration or a few paragraphs. They delivered text, references, tables and graphics to their Integrating Author/s by agreed dates, and according to agreed formats. They may have been requested to assist in addressing reviewer comments relating to the specific text they provided. Corresponding Authors did not attend writing meetings.

10. PEER AND STAKEHOLDER REVIEW PROCESS

The FODs of each Chapter, written by the multi-author teams, were sent to a minimum of two, and a maximum of six, peer reviewers. The expert peer reviewers were identified from existing scientific publications collected throughout the process and through nominations from the management team, general stakeholders, the PEC and PCG and Chapter Authors. A total of 71 peer reviewers, from international, national and provincial government departments, NGOs, academia and research institutions; and the private sector provided peer review comment on the FODs. Of the 71 peer reviewers, 25 were drawn from South Africa and 46 from other regions of the world, such as the United States, Canada, Australia, the United Kingdom, the European Union and others.

The comments received for each Chapter followed a structured format. The expert peer review submissions were collated into a database for each Chapter, and sent to the author teams prior to the second multi-author team meeting in April 2015. Following incorporation of the comments made on the FOD Chapters, the SOD Chapters were redrafted and sent back to the peer reviewers along with the itemised responses to their comments on the FOD to check that their comments had been sufficiently addressed and at the same time they were released for stakeholder comment in July 2016. All responses to peer review and stakeholder comments have been available and are in the public domain via the project website: http://seasgd.csir.co.za/

The stakeholders were required to follow the same prescribed structure for commenting on the SOD Chapters, in which page and line numbers were provided for each comment. As for the expert reviewers, the stakeholder comments were required to be specific, clear and constructive, and where possible, backed up with references or evidence. The authors addressed the stakeholder comments individually and incorporate appropriate comments into the final scientific assessment.

11. PARTICIPATION

There were four ‘pathways’ for participation through the process. These were designed to be appropriate for various stakeholders. None of the pathways for participation were mutually exclusive of the others e.g. if an individual were a member of the PCG, there was no restriction on participating in the process as a stakeholder by attending public meetings or making comments on draft material. The four pathways were: A.) Through project governance structures (discussed in Section 8); B.) Through the generation of salient questions to define the scope of the assessment; C.) Through the actual content generation of the assessment, developed using the highly inclusive the multi-author team approach (discussed in Section 9); D.) Through stakeholder commentary, public outreach and the review of draft content materials (discussed in Sections 4 and 10).

The 17 specific topics addressed in the scientific assessment were generated by a combination of ‘top down’ and ‘bottom up’ dialogs (Figure 4). ‘Candidate’ topics were gleaned from reviews of SGD literature housed in an extensive electronic library developed specifically for the assessment over 12 months. Topics were then debated and revised, were necessary, by the project governance structures and with stakeholders in public deliberation. The questions of the broader public were gathered in early rounds of three local community meetings in the Central Karoo and a consultative workshop with registered stakeholders in Cape Town in November 2015.

In July 2016, before finalisation of the scientific assessment report, the draft findings were presented to the same local and stakeholder communities to check that the key questions which had been raised in November 2016, had been adequately addressed. Feedback was incorporated via the standard review process (i.e. page/line numbered comments) and facilitated where necessary by capturing verbal input at the meetings for stakeholders without access to internet. Throughout the process, the management team used multiple communication mediums such as face-to-face meetings, the publication of written documents, explanatory video graphics and materials on the project website, interviews with the media and press releases and even novel approaches to raising awareness such as art exhibitions.

The primary, by not exclusive, means of communication was via the project website (http://seasgd.csir.co.za/), launched on 13 May 2015 following the parliamentary launch of the SEA. By the time of the scientific assessment publication, there were in excess of 600 registered stakeholders (Figure 8). This was a deliberate result of public outreach meetings over this period, where meetings were widely advertised through national and local radio stations, direct liaison with municipalities, the release of flyers to local communities, bulk sms distribution, newspaper adverts in provincial and local media houses, social media notices such as Facebook, dissemination of notice through government channels such as South African Local Government Agency and members of the PEC and PCG. Figure 9 provides the geographical distribution of stakeholders who participated in the process.

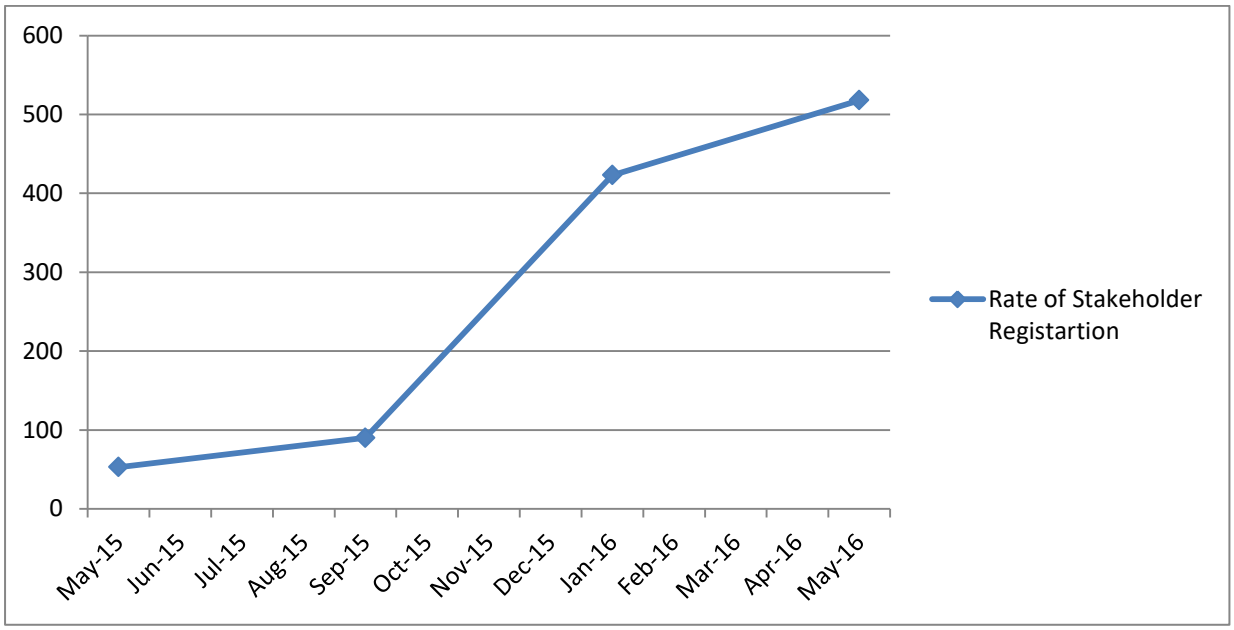

Figure 8: The rate of stakeholder registration over a 12 month period from May 2015 to May 2016. From the date of the launch until end-June 2015, the management team received 53 online registrations. During the period between early-July and end-September a further 37 online registrations were

received. During the period between early-October 2015 and end-Jan 2016 there was a substantial increase in online registration; the management team received 333 registrations.

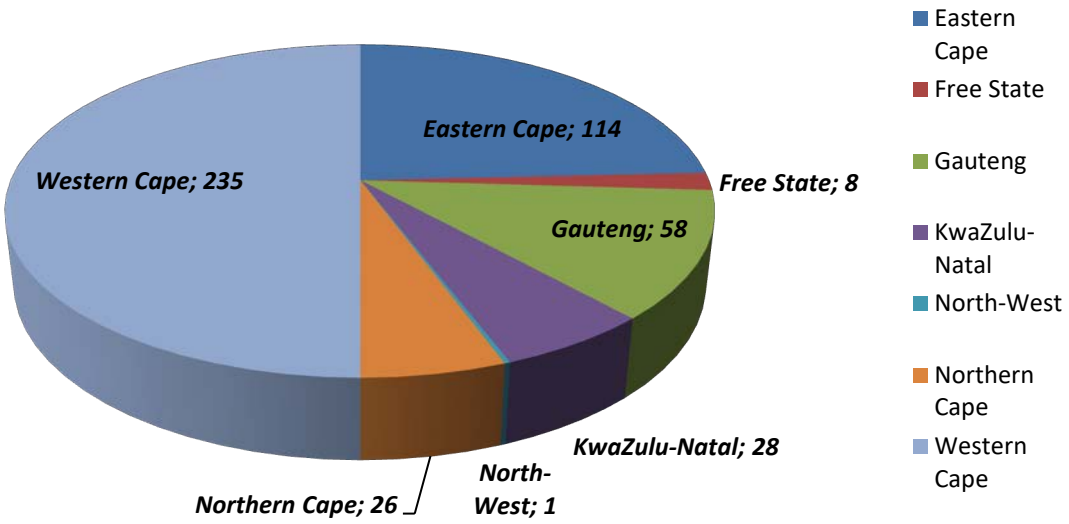

Figure 9: Registered stakeholders were resident in seven of the provinces, most of them based in the Western Cape. A number of online registrations did not indicate their province and cities therefore they have not been accounted for in the figure. In the Eastern Cape most of the stakeholders were based in Graaff-Reinet and Port Elizabeth, in the Free State the majority were from Bloemfontein, in Gauteng there is an equal split between Pretoria and Johannesburg. In KwaZulu-Natal the majority of stakeholders were based in Durban and a few in Pietermaritzburg. Victoria West had most of the stakeholders in Northern Cape, and the Western Cape was roughly equal between Beaufort West and Cape Town.